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(54) Method for manufacturing a photo diode for a CCD image sensor

(57) A method for manufacturing a photo diode of a CCD image sensor, comprises the steps of forming an oxide layer on an N^- type substrate; implanting N^+ ions into a selected portion of the N^- type substrate to form a N^+ type buried region; growing a P type epitaxial layer between the N^- type substrate and the oxide layer; forming P^+ type channel stop regions by implanting P^+ ions into selected portions of the P type epitaxial layer; and forming a N^+ type photo diode region and a N^- type well between the P^+ type channel stop regions, the N^+ photo diode being formed over the N^+ type buried region.

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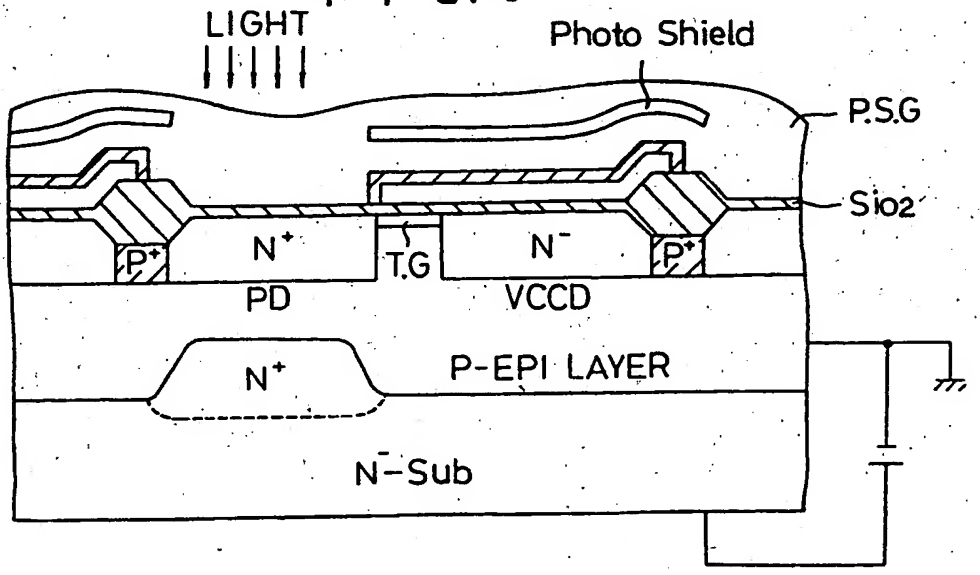

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FIG. 1
PRIOR ART

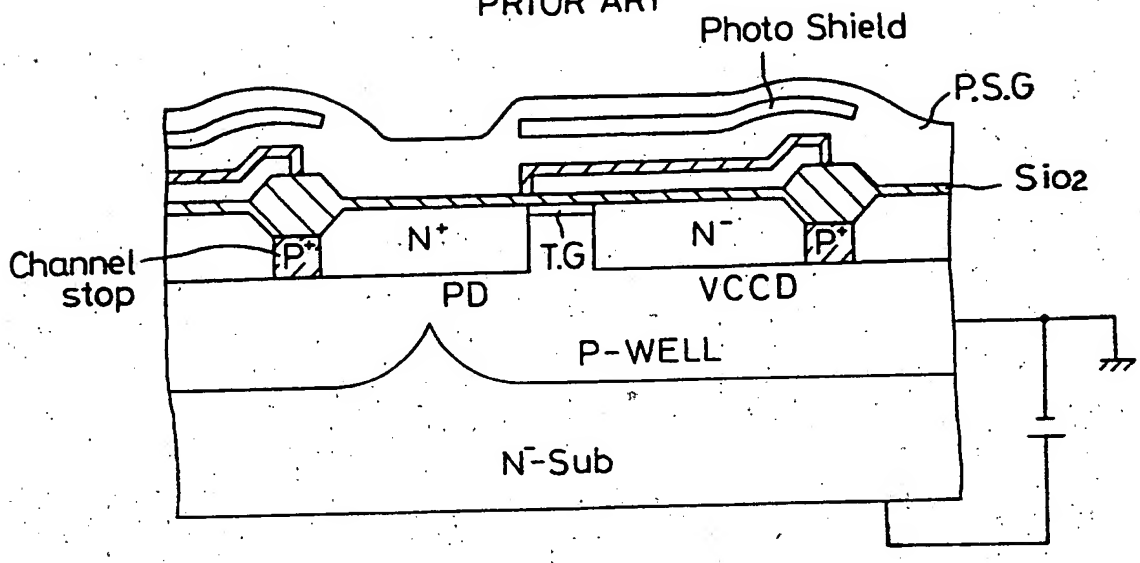


FIG. 2A
PRIOR ART

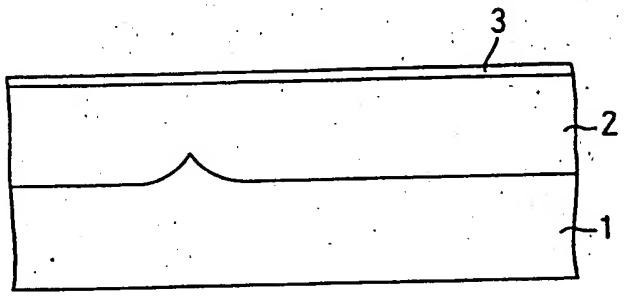


FIG. 2B
PRIOR ART

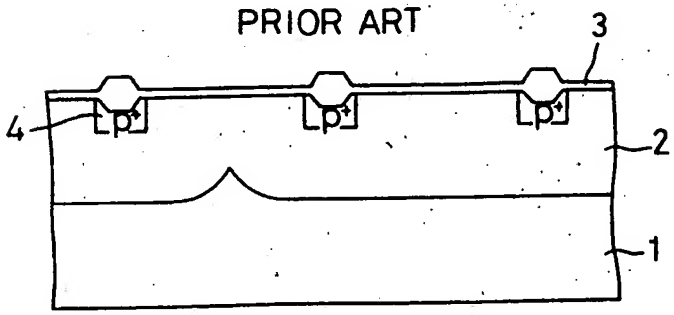


FIG. 2C
PRIOR ART

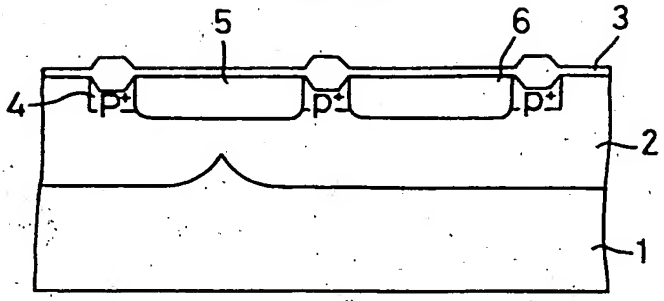


FIG. 2D
PRIOR ART

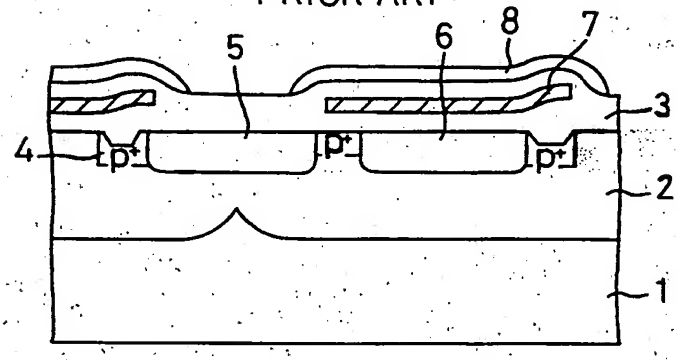


FIG. 3
PRIOR ART

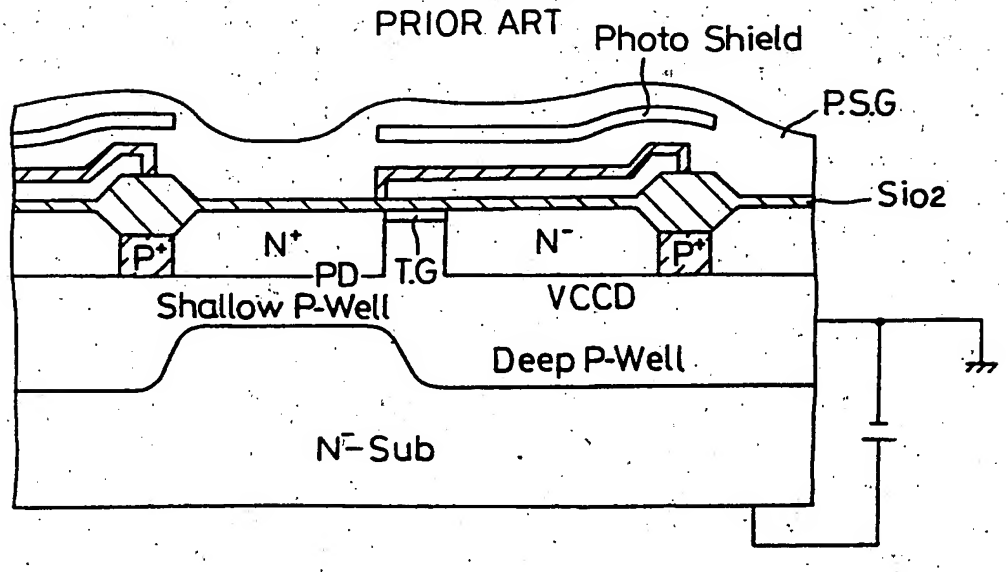


FIG. 4E
PRIOR ART

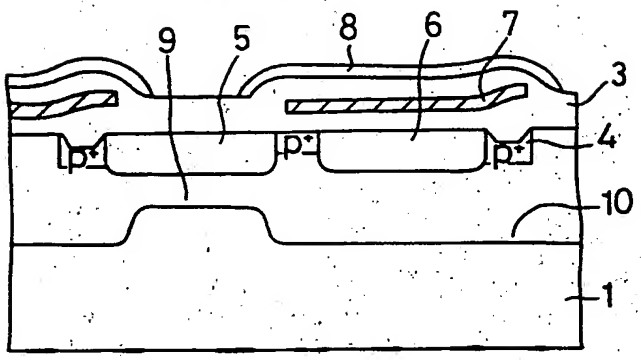


FIG. 5
PRIOR ART

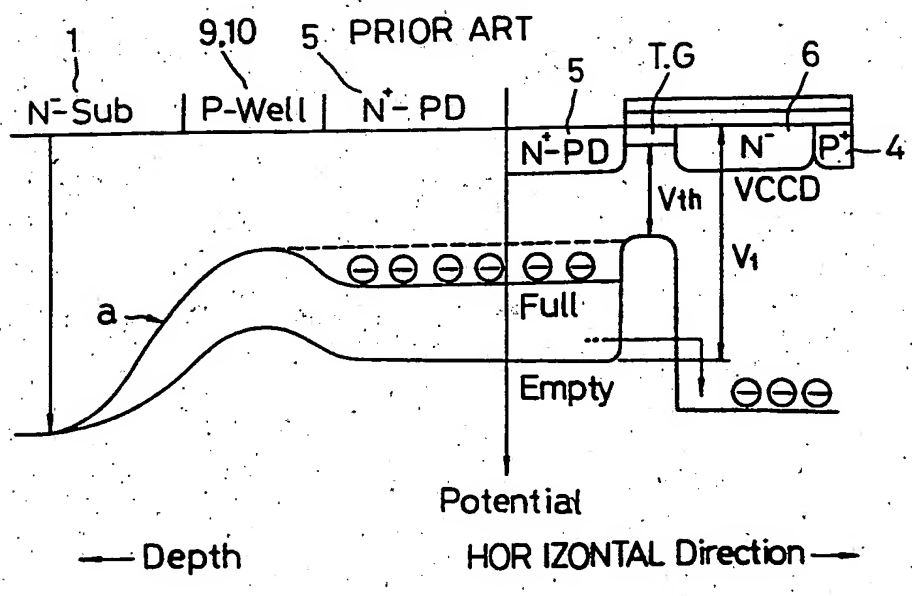


FIG. 4A
PRIOR ART

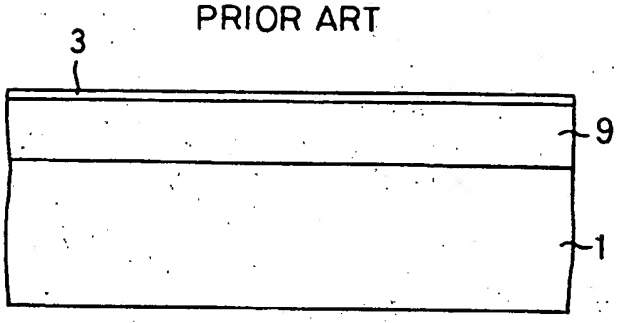


FIG. 4B
PRIOR ART

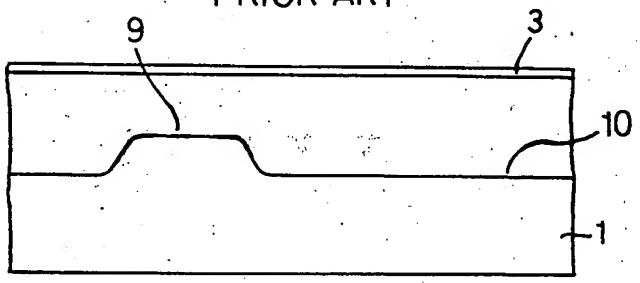


FIG. 4C
PRIOR ART

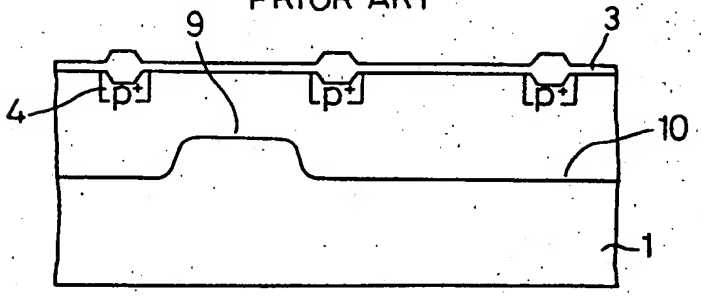


FIG. 4D
PRIOR ART

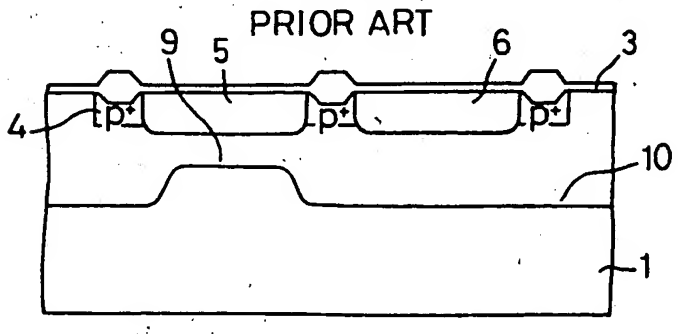


FIG. 6

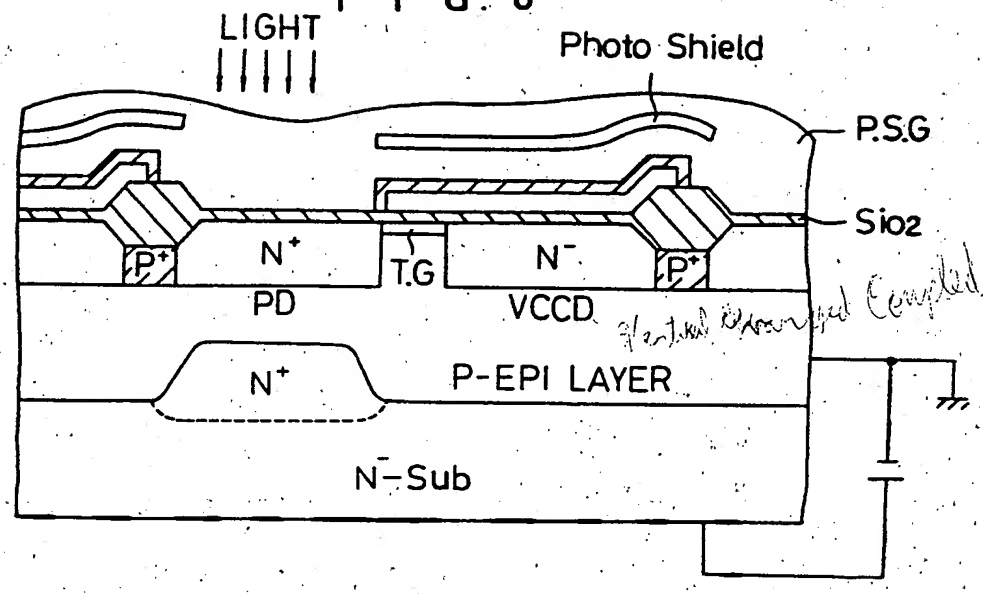


FIG. 7A

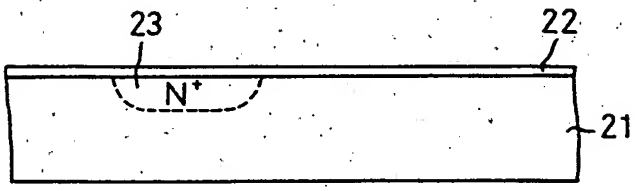


FIG. 7B

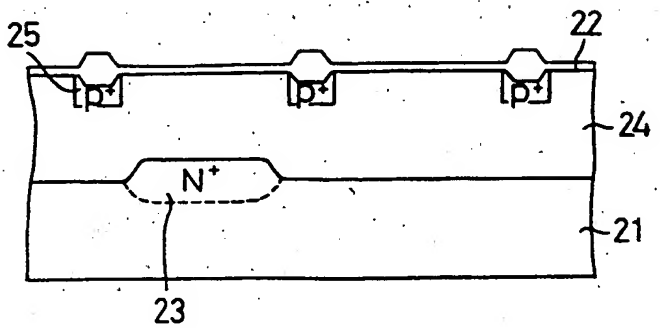


FIG. 7C

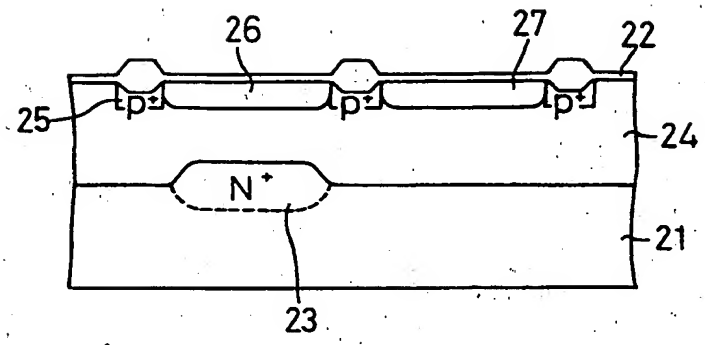


FIG. 7D

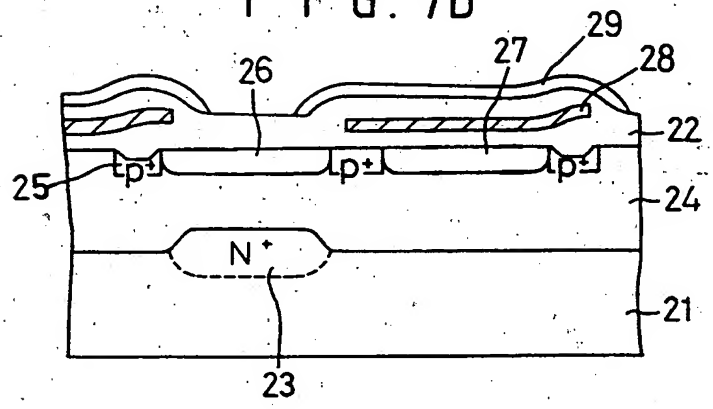
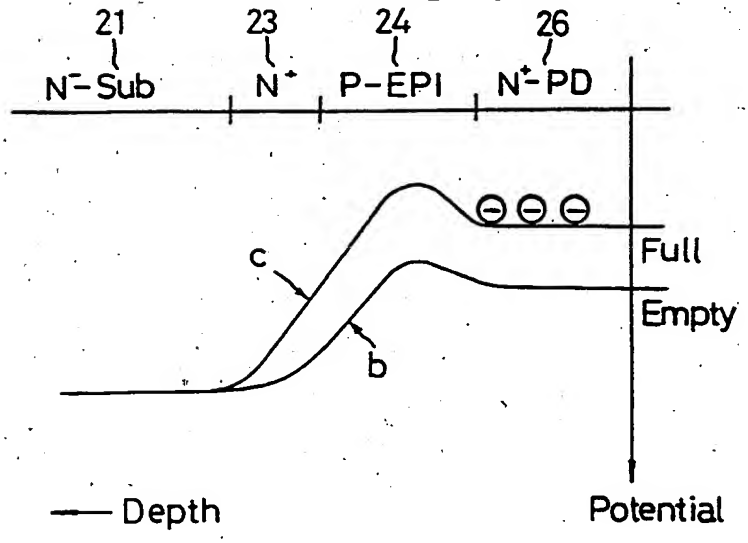


FIG. 8



METHOD OF MANUFACTURING A PHOTO DIODE FOR A CCD IMAGE SENSOR

The present invention relates to a method of manufacturing a photo diode for a charge coupled device (CCD) image sensor, and more particularly to a method for manufacturing a photo diode so as to limit over flow drain (OFD).

Conventionally photo diodes in CCD image sensors are constructed as shown in Fig. 1 or Fig. 3 and the process steps for fabricating the CCD image sensor of Fig. 1 are shown in Figs. 2A to 2D. As shown in Fig. 2A, a P type well region 2 is formed on N^- type substrate 1 and an oxide layer 3 is formed on the P type well region 2. P^+ type regions 4 are formed by implanting phosphorus ions as shown in Fig. 2B. As shown in Fig. 2C, a N type photo diode region 5 and a N^- type well region 6 are formed therebetween, respectively. Polysilicon layer 7 and aluminium layer 8 are formed as shown in Fig. 2D. The process steps described above are inconvenient because it is difficult to adjust the depth below the N^+ type photo diode region 5 of the P type well region 2 where it forms a cusp shape as shown.

The process steps for fabricating the CCD image sensor of Fig. 3 are shown in Fig. 4A to Fig. 4E. A shallow P type well region 9 is formed on N^- type substrate 1 and an oxide layer 3 is formed on the shallow P type well region 9 as shown in Fig. 4A. A deep P type well region 10 is formed in the shallow P type well region 9 leaving a shallow P type well region for forming the photo diode, as shown in Fig. 4B. Thus, the shallow P type well r gion 9 has a flat profile rath r than being formed as a

cusp shape as in Fig. 1. P^+ type regions 4 are formed by implanting phosphorus ions as shown in Fig. 4C. After the ion implantation, a N^+ type photo diode region 5 and a N^- type well region 6 are formed therebetween as shown in Fig. 4D, and then polysilicon layer 7 and aluminium layer 8 are formed as shown in Fig. 4E. The process step of Figs. 4A to 4E can be performed more easily than the process steps of Figs. 2A to 2D; but, there is a disadvantage in that the number of the process steps are increased.

The operation of the conventional structure will be explained referring to Fig. 5. If electrons are accumulated in the N^+ type photo diode region, the electron concentration in the N^+ type photo diode is as shown by the curve. When a potential V_1 is generated in the N^+ type photo diode by applying threshold voltage V_{th} to Transfer Gate TG, the electrons in the N^+ type photo diode flow into the N^- type well region forming the vertical charge coupled device (VCCD).

As the impurity concentration in the N type substrate is higher than that of the P type well region, that of the P type well region being higher than that of N^- type substrate, the electrons released by incident light may recombine in the N^- type region. As a result, it is difficult to limit OFD due to the process step used for forming the P type well region.

Accordingly, the present invention provides a method of manufacturing a photo diode for a CCD image sensor, comprising the steps of providing a N^- type substrate; forming an oxide layer on the N^- type substrate; implanting N^+ ions into a selected portion of the N^- type substrate to form an N^+ type buried region; growing a P type epitaxial layer between the N^- type substrate and the oxide layer; forming P^+ type channel stop regions by implanting P^+ ions into selected portions of the P

type epitaxial layer; and forming a N^+ type photo diode region and a N^- type well between the P^+ type channel stop regions, the N^+ type photo diode region being formed over the N^+ type buried region.

In another aspect, the invention provides a photo diode for a CCD image sensor comprising a N^- type substrate; a P type epitaxially grown layer on the substrate; a N^+ type buried region between the substrate and the P type epitaxial layer; P^+ type channel stop regions in the P type epitaxial layer; a N^+ type photo diode region and a N^- type well between the P^+ type channel stop regions; the N^+ type photo diode region being formed over the N^+ buried region.

In the accompanying drawings:

Fig. 1 and Fig. 3 are cross sectional views of a photo diode in a conventional image sensor;

Fig. 2A to Fig. 2D are cross sectional views of the process steps for fabricating a CCD image sensor as in Fig. 1;

Fig. 4A to Fig. 4E are cross sectional views of the process steps for fabricating a CCD image sensor as in Fig. 3;

Fig. 5 shows potential profiles under the photo diode of a conventional CCD image sensor;

Fig. 6 shows a cross sectional view of a photo diode in a CCD image sensor embodying the present invention;

Fig. 7A to Fig. 7D are cross sectional views of the process steps for fabricating the CCD image sensor as in Fig. 6;

Fig. 8 shows potential profiles under the photo diode of a CCD image sensor embodying the present invention.

An example of the present invention will now be described with refer nce to Fig. 6 to Fig. 8 of the accompanying drawings.

As shown in Fig. 7A, oxide layer 22 is formed on N^- type substrate 21 and then N^+ ions are implanted into a selection portion of the N type substrate 21 to form a N^+ type buried region 23.

A P type epitaxial layer 24 is then grown between the N^- type substrate 21 and the oxide layer 22 and P^+ type channel stop regions 24 are formed by implanting phosphorus ions into selected portions of the P type epitaxial layer 23 as shown in Fig. 7B.

N^+ type photo diode region 26 and N^- type well 27 are formed between the P^+ type regions 25, the N^+ type photo diode region 26 being formed over the N^+ type buried region 23, as shown in Fig. 7C. Then, polysilicon layer 28 and aluminium layer 29 are formed thereon by known techniques as shown in Fig. 7(D).

In the CCD image sensor fabricated as described above, the potential profiles under the photo diode are represented by the curves b, c in Fig. 8 and the inclination of the curves b, c can be changed according to the concentration of the ion implantation in the buried region 23. Thus, it is easy to meet overflow drain requirements since the range of impurity concentration of the buried region is widely variable. As the P type epitaxial layer, instead of a P type well region, is formed on the N^- type substrate, the distribution of impurity concentration in the CCD region is uniform so that image character is improved, and it is possible to obtain almost the same effect as with N^- type substrate/N type epitaxial layer/P type well region structures which have typically been used to overcome the uniformity problem.

Another merit of the present invention is that it is easy to optimise the photo diode as the impurity concentrations of the N^+ type photo diode region can be changed as required and the conventional P type well process is eliminated.

CLAIMS

1. A method of manufacturing a photo diode for a CCD image sensor, comprising the steps of providing a N^- type substrate; forming an oxide layer on the N^- type substrate; implanting N^+ ions into a selected portion of the N^- type substrate to form an N^+ type buried region; growing a P type epitaxial layer between the N^- type substrate and the oxide layer; forming P^+ type channel stop regions by implanting P^+ ions into selected portions of the P type epitaxial layer; and forming a N^+ type photo diode region and a N^- type well between the P^+ type channel stop regions, the N^+ type photo diode region being formed over the N^+ type buried region.

2. A method according to Claim 1, wherein the ion implantation to form the buried N^+ type region is controlled to provide a predetermined potential profile under the N^+ type photo diode region of the completed photo diode.

3. A photo diode for a CCD image sensor comprising a N^- type substrate; a P type epitaxially grown layer on the substrate; a N^+ type buried region between the substrate and the P type epitaxial layer; P^+ type channel stop regions in the P type epitaxial layer; a N^+ type photo diode region and a N^- type well between the P^+ type channel stop regions; the N^+ type photo diode region being formed over the N^+ buried region.

4. A method of manufacturing a photo diode for a CCD image sensor, substantially as hereinbefore described with reference to Figs. 6 to 8 of the accompanying drawings.

5. A photo diode for a CCD image sensor substantially as hereinbefore described with reference to and as illustrated in Figs. 6 to 8 of the accompanying drawings.

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